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WATER QUALITY ASSURANCE PLAN (WQAP) FOR HEALTH CENTER WATER SUPPLY

USAID/ETHIOPIA

ETHIOPIA HEALTH INFRASTRUCURE PROGRAM (EHIP) HEALTH CENTERS WATER SUPPLY

WATER QUALITY ASSURANCE PLAN

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Adapted for EHIP use by:

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PROJECT/ACTIVITY NAME: Ethiopia Health Infrastructure Program (EHIP) Water Supply

Notes:
1. For clearance to be granted, the activity MUST be within the scope of the activities for which use of the WQAP is authorized in the governing IEE. **Review IEE before signature.** If activities are outside this scope, deny clearance and provide explanation in comments section. The Partner, C/AOR, MEO and REA must then confer regarding next steps: activity re-design, an IEE or EA.

2. Clearing a WQAP containing one or more findings that **significant adverse impacts are possible** indicates agreement with the analysis and findings. It does NOT authorize activities for which "significant adverse impacts are possible" to go forward. It DOES authorize other activities to go forward. The Partner, C/AOR, MEO and REA must then confer regarding next steps: activity re-design, an IEE or EA.

Approval:

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Yitayew Abebe, Mission Environmental Officer Date

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DISTRIBUTION:

Tetra Tech, Engineering Services and Construction Oversight (ESCO) Contractor

EHIP Water Supply Awardees (TBD)

Contents

1. INTRODUCTION

USAID is working in partnership with the Ethiopia Ministry of Health to improve health infrastructure throughout Ethiopia as part of USAID's Ethiopia Health Infrastructure Program (EHIP). The program aims to improve access to and quality of health services in rural areas of the country. As part of the program, USAID will procure the services of a contractor(s) to construct and install complete water supply systems that will provide sufficient potable water at each of 11 health centers. Some of the health centers are already completed while other are still under construction. Currently, these health centers are neither connected to existing utility water supply systems nor have a potential separate source/system. The health centers are located in Amhara and Southern Nations, Nationalities and Peoples (SNNP) regional states. The geographic locations of the health center sites are indicated in Table 1 below.

The planned water supply systems include the following main components:

- Source development which is solely from groundwater wells. The contractor(s) is expected to drill wells up to anticipated depths indicated in Table 1 below.
- Well yield estimation through pumping tests.
- Water quality analysis including physical, chemical, and biological quality testing.
- Construction and completion of wells that are accepted by USAID after their consideration of yield and water quality test results. This includes installation of casing, screen, gravel packing, well development, and wellhead construction.
- Installation of electro-mechanical equipment including submersible pump, riser pipe, control panel, and well level control system installation.
- Connection of wells to elevated water tanks constructed by others. This includes installation of pipeline between the wellheads and the elevated tanks.
- Installation of photovoltaic (PV) systems to power the well pumps.

As part of the service, the contractor(s) shall be responsible to ensure water delivered from the groundwater wells undergo water quality testing and analysis based on acceptable international, national, and USAID's requirements. The contractor(s) shall be responsible for conducting or sub-contracting water quality testing to a qualified analytical laboratory to conduct the required water quality testing. The purpose of this Water Quality Assurance Plan (WQAP) is, therefore, to outline the requirements to the contractor(s) to assure proper water quality testing, analysis, and recommendations.

Table 1: Health Centers Location and Anticipated Well Depths

Health Center	UTM 37P		Graded Elevation (m)	Anticipated Well Depth (m)
	Easting (m)	Northing (m)		
Addis Betechristian	373828	1324668	1871.0	150
Agumamit	296300	1179721	1921.0	190
Gelsha	560225	1215584	2965.0	150
Gerbicho	438303	723734	2069.0	180
Gulem Dejen	292430	1170870	1984.0	150
Gult	373114	1257952	2348.0	180
Haro	405622	678238	2018.0	120
Kachena Gudie	241267	1234551	1834.5	120

Health Center	UTM 37P		Graded Elevation (m)	Anticipated Well Depth (m)
	Easting (m)	Northing (m)		
Kuni	304027	1193590	2258.5	170
Lideta	267457	1210328	2517.0	150
Maksegnit	378374	1250205	2281.0	300

Initial assessment indicates that water quality of the planned groundwater well based water supply systems at the health centers could be potentially affected by the following:

- Inherent geological/hydrogeological conditions inside the health centers compounds or surrounding area of influence
- Potential pollution from sources within the health centers compound such as:
    - Pit latrines
    - Septic tanks
    - Soak-away pits or sand mounds
    - Placenta pits
    - Other contaminant sources
- Similar facilities in the neighboring fields/plots (if available)
- Farms or agricultural activities in neighboring fields/plots
- Runoff from surrounding areas
- Other sources of contamination.

As part of the Water Quality Assurance Plan (WQAP), the contractor(s) shall conduct a comprehensive assessment of the above potential contaminant sources within 200m around the groundwater wells. The contractor(s) is(are) encouraged to review drawings and other relevant information related to the health centers to acquaint itself of the various facilities that are available in the health centers compounds. The location of the groundwater wells shall be in such a way that potential contamination from these sources is averted. The minimum distance between the wells and contaminant sources is 30m. Also, other mitigation measures such as increasing well grouting depth shall be considered. Any change in the location of the groundwater wells shall be communicated to USAID for approval.

2. USAID RECOMMENDED WATER QUALITY PARAMETERS

Based on experience from previous projects and in line with other water quality standards (such as USEPA and WHO) USAID has identified water quality parameters that need particular attention. These parameters are listed in the table below. Further, justification for inclusion of these parameters is provided in the table.

Table 2: USAID Recommended Water Quality Parameters

Water Quality Parameter	Justification for Inclusion	Maximum Permissible Level
Arsenic (As)	Arsenic is a naturally-occurring metalloid found in many parts of the world. Consumption of arsenic at high concentrations can lead to death, while long-term exposure at lower concentrations through drinking water	0.01 mg/lt

Water Quality Parameter	Justification for Inclusion	Maximum Permissible Level
	sources can lead to a severe chronic illness called arsenicosis. Long-term exposure can result in thickening of the skin, darker skin, abdominal pain, diarrhea, heart disease, numbness and cancer. Following the discovery of several cases of arsenicosis as a result of USAID-funded water supply programs in the 1990's, the Agency now requires the testing of arsenic in all water supply programs.	
Fecal coliform	Fecal coliform, specifically Escherichia coli (E. coli), is the most common waterborne pathogen linked to diarrheal disease and is associated with human or animal waste. The World Health Organization (WHO) estimates that diarrheal disease causes 1.5 million deaths annually, affecting mainly children in developing countries. Approximately, 58% of these deaths are attributable to unsafe water supply, sanitation and hygiene. Other diseases that can be transmitted by contaminated water include typhoid fever, cholera, salmonellosis, dysentery, and botulism, as well as viral diseases including SARS, Hepatitis A, and Polio.	Zero
Fluoride (F-)	Fluoride is a naturally-occurring anion of fluorine which occurs in minerals and fluoride salts. In small quantities, fluoride can be helpful to human health and protect from tooth decay. However, in higher concentrations (above several parts per million), fluorides can cause pitting of teeth and skeletal problems including crippling fluorosis, anemia and stiff joints. Heavy concentrations of fluoride can be found naturally throughout northern Africa, the Middle East and central Asia.	4.0 mg/lt
Nitrate (NO3-)	Nitrate (NO3-) is an inorganic compound that occurs naturally or is produced synthetically, and is commonly used in fertilizer. The consumption of high concentrations of nitrate (greater than 45 mg/L of NO3-) and the subsequent reduction of nitrate to nitrite (NO2-) can lead to methemoglobinemia, particularly in infants. The presence of nitrite in the blood converts hemoglobin to methemoglobin, which cannot carry oxygen and can lead to brain damage or death at high enough concentrations.	10.0 mg/lt
Electro-conductivity	Conductivity is a measure of the ability of water to pass an electrical current, and is determined by the inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Healthy freshwater systems have a range of 150 and 500 µhos/cm	No guideline value

Water Quality Parameter	Justification for Inclusion	Maximum Permissible Level
	(microsiemens per centimeter), but may vary greatly depending on the geology and mineral deposits. Sharp changes to electro-conductivity from baseline condition can indicate an influx of wastewater from industrial or agricultural activity.	
Total Dissolves Solids (TDS)	TDS is closely related to conductivity and is a measure of all ion particles that are smaller than 2 microns (0.0002 cm), and is a close approximation of salinity (although dissolved organic matter and other compounds may be included in the TDS measurement). High TDS can also indicate high alkalinity or hardness. Sharp changes to the TDS indicate changes to the overall water quality.	500 mg/lt
pH	pH is a measure of the balance between hydrogen ions (H+) and hydroxide ions (OH -), with a pH of 7.0 being neutral. Surface water sources normally range from a pH of 6.5 to 8.5, while groundwater sources can range from 6 to 8.5. In general, water with a low pH (< 6.5) could be acidic and corrosive, and could lead to elevated levels of metals as a result of the leaching of metals such as iron, manganese, copper, lead, and zinc from the aquifer, plumbing fixtures, and piping. Waters with higher alkalinity (a pH > 8.5) indicate hardness (high concentration of dissolved minerals, particularly calcium and magnesium) and could contribute to mineral deposits on the water piping. Although hardness is not a health concern, it can result in distasteful water.	6.5 – 8.5
Turbidity	Turbidity is a measure of the clarity or cloudiness of water and could be caused by silt, sand, mud, chemical precipitates, algae, bacteria, and other microscopic organisms. Turbidity is a quick and easy indicator of particulate or contaminant loading.	5 NTU

The first four parameters in the table above are health related while the last four are operational parameters. Other potential water contaminants of concern include heavy metals including iron, cadmium, mercury, lead, and chromium as well as pesticides and industrial chemicals, all of which can be found in drinking water sources, and can lead to a variety of health risks. Heavy metals are often present in drinking water sources as a result of mining operations or other industrial activities, while agricultural chemicals can be found in runoff in rural areas or infiltrate into groundwater sources. USAID recommends an investigation of potential sources of contamination at each health center site, in order to determine potential risks that should be monitored during the project implementation phase.

3. ETHIOPIAN REGULATORY REQUIREMENTS

The Federal Ministry of Water, Irrigation, & Electricity (MoWIE) and Ethiopian Standard Agency (ESA) published drinking quality standard at different times. These standard are compulsorily referred to ensure water quality for drinking purpose in the country. The Ethiopian Standard Agency's requirements are recently updated and are more rigorous compared to the earlier MoWIE standard. Thus, the ESA's requirement published in CES 58 – Compulsory Ethiopian Drinking Water Standard (2013) shall be considered, as indicated in tables 3, 4, 5, and 6 below.

Table 3: Physical Characteristics of Drinking Water

Substance or characteristic	Maximum Permissible Level	Test method
Odor*	Unobjectionable	ES 605
Taste	Unobjectionable	ES 605
Turbidity, NTU	5	ES ISO 7027
Color, TCU	15	ES ISO 7887

* Threshold number, Max. = 3

Note 1: The above table was included in the earlier version of the standard: ES 206:2001.

Table 4: Characteristics that Affect Palatability of drinking Water

Substance or characteristic	Maximum Permissible Level	Test method
Total hardness (as $CaCO_3$)	300	ES 607
Total dissolved solids mg/l, Max	1000	ES 609
Total Iron (as Fe) mg/l, Max	0.3	ES ISO 6332
Manganese (as Mn) mg/l, Max	0.5	ES ISO 6333
Ammonia (NH +NH+)* mg/l, Max	1.5	ES ISO 7150-2
Residual, free chlorine mg/l, max	0.5	ES ISO 7393
Anionic surfactants, as mass concentration of MBAS mg/l, Max	1.0	ES ISO 7875-1
Magnesium (as Mg) mg/l, Max	50	ES ISO 7980
Calcium (as Ca), mg/l, Max	75	ES ISO 7980
Copper (as Cu) mg/l, Max	2	ES ISO 8288
Zinc (as Zn) mg/l, Max	5	ES ISO 8288
Sulfate (as SO4) mg/l, max.	250	ES ISO 9280
Chloride (as Cl), mg/l, Max	250	ES ISO 9297
Total alkalinity (as CaCO3) mg/l, Max	200	ES ISO 9963-1
Sodium (as Na), mg/l, Max	200	ES ISO 9964-1
Potassium (as K), mg/l, max	1.5	ES ISO 9964-2
pH value, units	6.5 to 8.5	ES ISO 10523
Aluminum (as Al) mg/l, Max	0.2	ES ISO 12020

* The term ammonia includes the non-ionized (NH_3) and ionized (NH^+_4) species.

Note 2: Several of the inorganic elements for which maximum permissible levels has been settled are recognized to be essential elements in human nutrition. No attempt has been made here to define a minimum desirable concentration of such substances in drinking water.

Table 5: Content of Toxic and/or Disease Causing Substances of Drinking Water

Substance or characteristic	Maximum Permissible Level	Test method
Barium (as Ba) mg/l, Max	0.7	ES 606
Total mercury (as Hg) mg/l, Max	0.001	ES ISO 5666-3
Cadmium (as Cd) mg/l, Max	0.003	ES ISO 5961
Arsenic (as As) mg/l, Max	0.01	ES ISO 6595
Cyanide(as CN) mg/l, Max	0.07	ES ISO 6703-1
Nitrite as NO2), Mg/l, Max	3	ES ISO 6777
Nitrate as NO3 Mg/l, Max	50	ES ISO 7890-3
Phenolic compound as phenols, mg/l, Max.	0.002	ES ISO 8165-1
Lead (as Pb) mg/l, Max	0.01	ES ISO 8288
Boron (as B) mg/l, Max	0.3	ES ISO 9390
Selenium (as Se) mg/l, Max	0.01	ES ISO 9965
Fluoride (as F) Max	1.5	ES ISO 10359-1
Chromium (as Cr) mg/l, Max	0.05	ES ISO 11083
Pesticides and Organic Constituents, Mg/l, Max		
a) DDT	2	ES ISO 6468
b) Heptachlor and heptachlor epoxide	0.03	ES ISO 6468
c) Hexchchlorobenzene	1	ES ISO 6468
d) Lindane (Gamma - BHC)	2	ES ISO 6468
e) Methoxychlor	20	ES ISO 6468
f) Aldrin/Dieldrine	0.03	ES ISO 6468
g) 1,2 Dichloro ethane	30	ES ISO 10301
h) 1,1,1- Trichloro ethane	2001	ES ISO 10301
i) - Trichloro ethene	70	ES ISO 10301
j) Trichlorobenzenes (total)	20	ES ISO 10301
k) Hexachlorobutadiene	0.6	ES ISO 10301

Note 3: Because of the possibility of simultaneous occurrence of nitrite and in drinking water, the sum of the ratios of the concentration of each to its standard value should not exceed 1, i.e.

$$\frac{C_{nitrite}}{SV_{nitrite}} + \frac{C_{nitrate}}{SV_{nitrate}} \leq 1$$

Where, C is concentration and SV is standard value.

Note 4: The limit value for fluoride should consider climatic conditions, volume of water consumed and intake from other sources provided the limit specified in the above table is satisfied.

Table 6: Bacteriological Levels

Organism	Maximum Permissible Level	Test Method
Total viable organisms, colonies per ml	Must not be detectable	ES ISO 4833
Fecal streptococci per 100ml	Must not be detectable	ES ISO 7899-1
Coliform organisms, number per 100 ml	Must not be detectable	ES ISO 9308-1
E. Coli, number per 100 ml	Must not be detectable	ES ISO 9308-1

4. WHO GUIDELINE VALUES

The World Health Organization (WHO) published an updated Guideline for Drinking Water Quality (2017) Fourth Edition Including the First Addendum. The document can be obtained through http://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/. The latest revision includes microbial hazards and chemical contaminants in drinking water not considered previously. Further, it accounts for climate change which is changing previously relevant patterns which have impact on water management strategies.

The WHO guideline values are mostly similar to USAID's and Ethiopian requirements. However, there are changes in guideline values of certain parameters which should only be considered where there is sufficient location specific reasons to justify the variation.

5. RATIONALE FOR SELECTION OF SITE SPECIFIC WATER QUALITY PARAMETERS

Considering site specific information priority shall be given to parameters that are more applicable to the project sites, i.e. the 11 health centers. Generally, the project health centers are located in rural settings where industrial and modern agriculture is rarely practiced. Thus, groundwater contamination from industrial effluents and agricultural inputs (pesticide, herbicide) is very limited. The potential sources of contamination in the health centers areas are:

- Inherent geological/hydrogeological characteristics of the project areas of influence
- Contamination from agricultural practices such as subsistence farming and domestic animals rearing
- Contamination from human and animal excreta
- Contamination through transported materials through runoff.

In addition to the above, the capacity of the available regional and federal laboratories to conduct tests and analysis shall be accounted for in the plan.

Considering the above, the following parameters are prioritized for testing and monitoring.

Physical Parameters/Characteristics

- Odor
- Taste
- Color
- Turbidity

Chemical Parameters

- Total Dissolved Solids (TDS)
- Electrical conductivity
- pH
- Ammonia
- Sodium
- Potassium
- Calcium
- Magnesium
- Total hardness
- Fluoride
- Chloride
- Nitrate
- Nitrite
- Total iron
- Manganese
- Aluminum
- Arsenic
- Chromium
- Copper
- Zinc
- Boron
- Sulfate

Biological Parameters

- Total coliform
- Fecal coliform
- E. coli

6. FREQUENCY OF TESTING

The frequency of sampling and analysis considered the following factors:

- After completion of well drilling, information on water quality is necessary to identify parameters that exceed the maximum permissible levels and decide whether to continue on constructing and developing the well.
- After completion of the well and the entire system and after disinfection of the same, there is a need to test the quality water to assess whether it is potable for drinking purpose or not.
- Frequency of sampling and testing considered that the most important parameters to frequently test are those that pose significant health hazards. This mainly includes biological parameter such as fecal coliform and certain chemical parameters such as Fluoride, Nitrate, Nitrite, and Arsenic.
- Frequency of sampling and testing considered USAID's and national requirements as well as WHO's recommendations.

Considering the above points, sampling and testing frequency shall be as indicated in the following table.

Table 7: Minimum Frequency of Sampling & Analysis

Parameter Group	Parameter to be Tested	Minimum Frequency of Sampling & Analysis	Number of Samples to Test*
Physical	Odor Taste Color Turbidity	(1) After drilling is completed (before well installation & completion) (2) After completion of the water supply system and just before commissioning, i.e. at *Final Acceptance* (3) Every three (3) months after *Final Acceptance*, i.e. during warranty period	Two (2)
Chemical	<u>Health related parameters</u>: Fluoride Nitrate Nitrite Arsenic	(1) After drilling is completed (before well installation & completion) (2) A confirmatory test shall be taken if results from the above test indicates exceedance of maximum permissible levels (3) After completion of the water supply system and just before commissioning, i.e. at *Final Acceptance* (4) Every three (3) months after *Final Acceptance*, i.e. during warranty period	Two (2)
	<u>Operational & other parameters+</u>: Total Dissolved Solids (TDS) Electrical conductivity pH Ammonia Sodium Potassium Calcium	(1) After drilling is completed (before well installation & completion) (2) After completion of the water supply system and just before commissioning, i.e. at *Final Acceptance* (3) Every three (3) months after *Final Acceptance*, i.e. during warranty period	Two (2)

Parameter Group	Parameter to be Tested	Minimum Frequency of Sampling & Analysis	Number of Samples to Test*
	Magnesium Total hardness Chloride Total iron Manganese Aluminum Chromium Copper Zinc Boron Sulfate		
Biological	Total coliform Fecal coliform E. coli	(1) After drilling is completed (before well installation & completion) (2) A confirmatory test shall be taken if results from the above test indicates exceedance of maximum permissible levels (3) After completion of the water supply system and just before commissioning, i.e. at *Final Acceptance* (4) Every three (3) months after *Final Acceptance*, i.e. during warranty period (5) If results above indicates exceedance of maximum permissible levels, then the testing frequency shall be every one (1) month after corrective measures are taken	Two (2)

*When circumstances allow, it is advisable to take two samples for analysis of parameters indicated above. As much as possible, conduct analysis at different laboratories or one of the analyses could be made on site. If sample analysis if found to be reliable then the number of samples to analyze can be reduced to one (1).

+Although parameters such as Chromium, Copper, & Boron health hazards their presence and expected concentration levels are considered to be limited for the current project and thus rigorous testing regime is not necessary.

7. SAMPLE COLLECTION AND FIELD MEASUREMENT

The contractor(s) shall manage and coordinate water quality sampling and field measurements. The contractor(s) shall provide information on its employees and sub-contractors including trained personnel assigned to collect water samples and to conduct field measurements.

TRAINED PERSONNEL

The contractor(s) shall provide a brief narrative addressing the following items:

- Identify its own qualified personnel who can perform sampling and field measurements.
- Identify available qualified technicians from local health clinics, government offices, or local water

management committees who can perform sample collection and field measurement.

- Describe the qualifications for each technician.
- Identify local beneficiaries who can be trained to perform these tasks.

SAMPLING AND TESTING EQUIPMENT

The Contractor shall provide a brief narrative describing the availability of appropriate equipment, based on the general guidelines below.

In general, sampling, transportation, and storage of samples for water quality testing/analysis shall conform with ES ISO 5667-11:2009. Key information on equipment requirement for sampling and field testing are indicated in this section.

The contractor(s) or its sub-contracting water quality laboratory shall provide the following equipment:

- Sampling equipment, including consumables (i.e. bottles or containers), PPE, bailers, coolers to be used.
- Refrigeration or ice making equipment for preserving samples.
- An office or clean area where samples can be processed.
- Portable test kits.
- Other equipment for sampling and field testing parameters.

Equipment and supplies used in the sampling shall include:

- Meter/portable kit for field measurements
- Spare parts (e.g. backup meter and electrodes)
- Batteries
- Standard buffer solutions for meter calibration (note expiration date)
- Deionized water
- Paper towels, tissues, or lab wipes
- Germicidal wipes or dilute bleach solution (1:6)
- Sample containers with labels
- Log book or computer
- Chain of custody forms
- Ziploc bags
- Strapping tape
- Cooler(s) with ice
- Sterile gloves
- Safety glasses
- Other safety equipment as needed
- Wrench or other tool to remove a cap, cover or enclosure
- Equipment to take sample safely, such as sampling pole with clasp for bottles, or sampling pump or bailer for wells.
- Sample bottles, including any preservatives, and labels can be ordered from the laboratory performing the analysis.
- Miscellaneous, expendable sampling supplies (e.g., ice, coolers, markers, calibration standards).

The contractor(s) shall coordinate with the selected laboratory to determine the necessary sample containers required for each water quality parameter. The following table provides a guideline on sample bottle type, preservative, and holding time for different water quality parameters. This information should be confirmed by the sub-contracting laboratory as required.

Table 8: Sample Bottle Requirements

Contaminant	Analytical Method	Bottle Type	Bottle Size	Preservative	Holding Time
Coliform	ES ISO 9308-1	Plastic	125 mL	thiosulfate (if chlorinated)	24 hours
Arsenic	ES ISO 6595	Plastic	500 mL/250 mL	EDTA/acetic acid	6 months
Nitrate/nitrite	ES ISO 7890-3	Plastic	variable	None	48 hours
Other physical/chemical parameters	variable	Plastic	variable	variable	6 months

PROCEDURES AND PROTOCOLS FOR COLLECTION, MEASUREMENT, SAMPLE PRESERVATION AND TRANSPORT TO LABORATORIES

The following procedures indicate typical sample collecting, field measurement, and transport methodologies. The contractor(s) should modify these procedures to suit actual site conditions.

Procedure 1: Planning Immediately before Sample Collection

1. Confirm that sample collection personnel have received all required training and certification (e.g. sample collection, safety).
2. Review sampling locations.
3. Identify site-specific safety considerations (e.g. handling preservatives, construction activity) and necessary safety equipment.
4. Assemble equipment and supplies.
5. Check functionality of field instruments (e.g., pH meter) and batteries.
6. Check expiration dates on standard buffer solutions.
7. Schedule field visit.
8. At least one week before the sampling day, call the laboratory to order sample bottles; check sample holding times and preservation requirements; review lab requirements for field duplicate samples and trip blank (i.e., reagent blank) samples to be provided by the lab; and days when samples are accepted.
9. Check meter calibration.
10. Clean cooler(s) with dilute bleach solution (1:6) and wipe dry.
11. Add ice to cooler(s).

Procedure 2: Labelling Sample Bottles

1. Affix an adhesive label to each sample bottle.
2. Before sample collection, add the following information to each label with an indelible (waterproof) marker:
    a) Project name or number
    b) Sampling site name and number
    c) Sampling date (mm/dd/yyyy)
    d) Sampling time

e) Lab sample number
f) Sampler initials
g) Preservative (yes/no)
h) Preservative (name)
i) Analysis type (name)

Procedure 3: General Sample Collection

1. Remove cap, cover, or enclosure.
2. Put on required safety gear (e.g., gloves and safety glasses).
3. Turn on water and let run with a steady stream for 3 to 5 minutes.
4. If possible, turn the water down to a thin stream (about the width of a pencil), then let the water run 1 minute.
5. If no tap or valve is present, ensure sample collected from center of discharge.
6. Rinse the sample bottle and discard if required (if no preservative is present).
7. Collect samples.

Procedure 4: Field Measurement of pH

1. Collect sample and pour into sample vial.
2. Measure pH using Standard Method 4500-H+ B (APHA 2012 or equivalent international standard).
3. Rinse the probe thoroughly with deionized water, and blot dry using a lab wipe or paper towel.
4. Place the meter in the sample vial and let it equilibrate.
5. Stir the sample if possible to promote sample equilibration.
6. Once the meter reaches equilibrium, record the pH and temperature in log book or computer and chain of custody form.

Procedure 5: Collection of Coliform Bacteria Sample

1. Label bottle.
2. Remove cap, cover, or enclosure.
3. Put on sterile gloves.
4. Open water valve completely and flush line with water running for 3 to 5 minutes.
5. Turn off the water and thoroughly clean inside and around water discharge pipe or faucet, as much as possible, with germicidal wipe or a dilute bleach solution (1:6).
6. Open water valve completely again and reflush line for 1 minute.
7. Reduce water flow rate to a thin stream (about the width of a pencil) for actual sample collection. The rate should be low enough to accurately fill to the 100 mL mark, avoid dislodging material from the pipe wall, and avoid splashing during the fill.
8. Remove plastic seal and cap from sterile bottle. Place bottle under the steady stream of water from the discharge. Do not touch inside of bottle and do not place the cap on any surface; cap must be held while collecting sample. Do not pre-rinse sample bottle as preservative will be lost.
9. Fill the bottle with water to the 100 mL mark, do not fill completely (leave approximately 1 inch of airspace).
10. Cap bottle.
11. Place sample bottle in Ziploc bag, and store in iced cooler.

Procedure 6: Preparing Sample Bottles for Shipment to Laboratory

1. Contact lab to confirm sample shipment schedule.

2. Package paperwork in a waterproof Ziploc bag and tape it to the inside lid of the cooler.
3. Check that all sample bottle caps are securely fastened and not leaking.
4. Check that each cooler does not weigh more than 25 kg.
5. Check that each cooler has adequate ice to maintain required temperature.
6. Close the cooler and secure with strapping tape if ready for final relinquish.
7. Place shipping label on outside of each cooler.
8. Deliver the sample bottles to the laboratory or relinquish to courier or shipping agent, indicating relinquishing on chain of custody form.

Procedure 7: Filling out the Chain of Custody Form

The laboratory will provide the chain of custody form which should be filled out in the field by the sampler. If not, then a standard form should be developed. The form documents:

1. When samples were collected in the field and received by the lab;
2. The sampler's name, company, contact information and certification status;
3. The sampler's signature and date;
4. Field methods used;
5. Problems or changed conditions observed by the sampler (e.g., leaking tap, washing activity); and
6. Field measurements (e.g., pH, temperature, conductivity).

8. LABORATORY ANALYSIS

QUALIFIED LABORATORY

Qualified laboratories that can perform water quality tests/analyses has been identified as shown in the table below. However, the contractor(s) shall confirm or identify one or more qualified laboratories located within a reasonable distance to receive and process samples for the selected parameters.

Table 9: Qualified Laboratories close to Project Health centers

Name of Laboratory	Type of Analyses	Physical Address and Phone Number	Certifications/ Qualifications
Debub Water & Irrigation Bureau	Physical, Chemical, Biological	Awassa, Ethiopia Menahariya Sub city +251462206364	Regional government owned bureau with the required qualification
Amhara Design & Supervision Works Enterprise	Physical, Chemical, Biological	Bahir Dar, Ethiopia Hidar 11 Sub city +251582180435	Regional government owned enterprise with the required qualification
Water Works Design & Supervision Enterprise	Physical, Chemical, Biological	Addis Ababa, Ethiopia +251116185516	Federal government owned enterprise with the required qualification

The contractor(s) should contact each laboratory identified above or other qualified laboratories before testing begins and review the laboratories QA/QC program. Typically, the lab QA/QC program shall include system used to verify whether the entire analytical process is operated within acceptable limits and whether the mechanism established to measure non-conforming method performance.

AVAILABILITY OF PROPER ANALYTICAL EQUIPMENT

During the planning stage, i.e. before sampling and testing begins the contractor(s) shall confirm resources available at the selected laboratories to ensure that they are capable of undertaking the required testing. This includes gathering information on equipment used to:

- Receiving/storing (refrigeration) the samples
- Analysis of the samples for the parameters of concern, and
- Disposal of reagents, disposables.

This information can be summarized in a table similar to the example shown below.

Table 10: Template for Laboratory Resources Register

Laboratory: (Name)				
Water Quality Parameter	Analytical Method	Instrument Make and Model	Receiving Protocol	Disposal Practices for Consumables

AVAILABILITY OF TRAINED PERSONNEL

The contractor(s) shall identify availability of trained personnel in the selected laboratories to undertake water quality testing. This includes:

- Identifying the qualified, trained technicians and managers at the laboratories.
- Describing their capacity and availability to process the number of samples planned for this program.

An example summary table describing the laboratory capacity is provided below:

Table 11: Template for Trained Laboratory Personnel Register

Staff Position	Qualifications	Comments
Lab Manager		
Deputy Lab Manager		
Quality Assurance Officer		
Lab Technicians		

REPORTING

The contractor's selected laboratory shall provide reports that show the results of the analyses. The report shall indicate the following:

- Source of sample
- Location
- Date of sample collection
- Date received
- Client name or ID number (if any)
- Laboratory ID number (if any)
- Results of the parameters tested
- Comparison with limiting guideline values
- Overall conclusion on the quality of water sample tested.

9. IMPLEMENTATION OF WATER QUALITY ASSURANCE PLAN

The aim of the Water Quality Assurance Plan (WQAP) Implementation Plan is to prepare a roadmap that will ensure acceptable drinking water quality is achieved through predefined set of actions during the planning, construction, and operation period of the project. The implementation plan identifies key performance/monitoring indicators, responsible bodies for each planned activity and the time of the action. The implementation plan is based upon the risk identified and measuring/testing regime set up in the earlier sections.

PLANNING PHASE

Planning is the most important step of the water quality assurance plan. Decisions taken at this stage will avoid or considerably reduce potential water quality issues during the life cycle of the project. The responsibility of ensuring all planning and design measures, which leads to acceptable drinking water quality for the health centers, are considered to lie with USAID/Engineer. The following points have been considered:

- As part of the design works undertaken, the locations of wells have been identified. Wells are located at least 30m away from any potential contaminant source in the health centers' compound and neighboring plots/properties. These contaminant sources include latrines, soak-away pits, sand mounds/percolation fields, septic tanks, placenta pits, waste disposal sites, farmlands, other agricultural lands, runoff area/paths, etc… The separation distance considers pathogens die-off period during transport through sub-surface formations.
- The typical well design specifies that a 10m deep sanitary grout seal shall be provided to prevent/hinder contaminant transport and ultimately to protect the wells against pollution. Further, a 2m radius concrete apron shall be provided around the wellhead to prevent seepage of contaminants to the immediate sub-surface environment.
- To provide protection, all wells are located either in the health centers' compound or in a fenced off offsite location. Activities that could lead to water contamination can be controlled and monitored in these compounds.

CONSTRUCTION PHASE

During the construction phase, the contractor is the main responsible party for implementing the water quality assurance plan as stated in this document. USAID/Engineer will participate in reviewing, suggesting, and approving the contractor's design documents, reports, and construction activities. Also, USAID/Engineer will participate in capacity building of the health centers' personnel or local institutions that will participate in water quality sampling, and testing. The main activities in this period are:

- Before commencing drilling, confirm the location of the wells taking into account the minimum 30m separation distance required between the wells and potential contaminant sources in the health centers' compound and neighboring plots/properties.
- If the above condition cannot be met due to presence of potential contaminants source in the zone, then propose a new location that satisfies the criteria indicated above.
- If it is difficult to identify well locations satisfying the minimum separation distance, consider other construction measures that will ensure protection of the well from contamination. Such measures include increasing depth of sanitary grout seal and avoid locating well screens shallower than 30m from the ground surface.
- The contractor is responsible for identifying personnel and institutions that can do sampling, field measurements, handling/transporting, and laboratory testing of water from the wells on its behalf. USAID/Engineer will assist in capacity building of health centers' personnel (or others) towards this task after the warranty period.
- The contractor is responsible in performing and monitoring water quality sampling, field measurements, handling/transporting, and laboratory testing of water samples from the wells. The contractor shall produce test results and water quality reports as part of this activity.
- The contractor is responsible to ensure all construction activities, materials, and equipment used in the project are with the required specification with the aim of attaining the desired water quality.

Detailed actions to be considered during this stage are indicated in the table below.

OPERATION PHASE

Ensuring water quality during the warranty period is primarily the responsibility of the contractor. USAID/Engineer will closely follow-up implementation of the water quality assurance plan during this period. Other stakeholders include the health centers' personnel, relevant district line offices (such as health, water, and land administration desks), and the communities served by the health center (beneficial communities). However, the contractor is responsible for communicating, informing, and coordinating the efforts of all stakeholders towards implementing the water quality assurance plan during this period. USAID/Engineer will be responsible, along with the contractor, for capacity building of the health centers' personnel or local institutions that will participate in water quality monitoring, sampling, and testing. The main activities in this period are:

- Monitor land use around the well during operation period including avoid locating potential contaminants sources within 30m radius of the wells. If such source is planned to be located in the neighboring plot/property, discuss with the owner to address the issue.
- The contractor shall continue water quality testing during the warranty period in accordance with frequency indicated in this water quality assurance plan. The contractor may use personnel and institutions that were identified in the implementation phase for sampling, field measurement, and laboratory testing.
- The contractor will be responsible for maintaining the system, as defined in the scope of work, during this period in a timely manner so that defects will not result in deterioration of water quality.

The following table summarizes the water quality implementation plan.

Table 12: Water Quality Assurance Plan (WQAP) Implementation Plan

Project Phase	Mitigation Plan	Monitoring Indicator	Action By	Time/Duration of Action
Planning Phase	Locate wells at least 30m away from contaminant sources	Design drawings, Technical specifications	USAID/Engineer	Design period
	Provide sanitary grouting seal and apron in the well design	Design drawings, Technical specification	USAID/Engineer	Design period
	Provide well protection zone or restriction of access around the well	Design drawings	USAID/Engineer	Design period
Construction Phase	Confirm well location to ensure the 30m separation distance	Design drawings, confirmation reports	Contractor USAID/Engineer (for approval)	Contractor's mobilization period/start of project
	Identify new well locations if the above condition cannot be met	Revised design drawing, Actual drilling sites	Contractor USAID/Engineer (for approval)	Contractor's mobilization period/start of project
	Revision of well typical design to accommodate location constraints indicated above	Revised design drawings	Contractor USAID/Engineer (for approval)	Contractor's mobilization period
	Identify personnel or institutions that can do water quality sampling and field measurements	Reports, company profiles	Contractor	Contractor's mobilization period
	Identify laboratories or institutions that can do laboratory analyses of water samples	Reports, company profiles	Contractor	Contractor's mobilization period
	Ensure construction waste including drilling fluids & fuel are properly stored and disposed away from the well	Visual inspection, photos, reports	Contractor	During drilling process
	Water quality testing and identifying of parameters that exceed permissible levels	Test results, reports	Contractor	After completion of drilling
	Implement corrective measures (if necessary) to improve water quality	Designs, visual inspection, completion reports, photos	Contractor USAID/Engineer (for approval)	During well completion/connection
	Construct and complete the well and the system in such a way that it ensures protection against contamination including	Visual inspection, completion reports, manufacturers	Contractor	During well completion/ connection and before commissioning

Project Phase	Mitigation Plan	Monitoring Indicator	Action By	Time/Duration of Action
	disinfection of the system at the end	product data sheets, certificates, test results, photos		
	Provide well protection zone or restriction of access around the well	Visual inspection, photos, reports	Contractor	After completion of construction works
	Water quality testing and identifying of parameters that exceed permissible levels	Test results, reports	Contractor	Before commissioning
	Capacity building of health centers' personnel	Trainings given, on-job demonstrations, reports	Contractor USAID/Engineer	During commissioning
Operation Phase	Water quality testing (periodic)	Test results, reports	Contractor	According to planned frequency of testing during warranty period
	Monitoring land use around the wells	Visual inspection, reports	Contractor	During warranty period
	Maintenance of the wellhead, apron, well equipment, pipeline, fittings, valves, and other system components properly and timely	Visual inspection, reports, photos	Contractor	During warranty period
	Capacity building of health centers' personnel on water quality monitoring	Trainings given, on-job demonstrations, reports	Contractor USAID/Engineer	During operation stage

10. CORRECTIVE MEASURES

If water quality tests performed during the construction phase of the project indicates that certain parameters exceed the permissible maximum levels and the extent of exceedance is expected to pose significant health hazards as determined by USAID, the following corrective measures will be considered. The contractor can identify and propose other measures as deemed appropriate for USAID's review and approval. However, the contractor shall consider measures indicated here and other proposed measures on a case-by-case basis so that measures are still within the scope of the current project.

HEALTH RELATED HAZARDS/PARAMETERS

Arsenic: If arsenic levels are exceeded, the contractor shall notify USAID and investigate alternative safe water sources since treatment for Arsenic, which involves coagulation, precipitation, or adsorption, is impractical for small scale water systems. If alternative sources are available, then:

- Access to the alternative source shall be provided (if authorized by the USAID CO); and,
- The drilled well with the exceedance shall not be considered for completion, connection, and groundwater withdrawal.

Fecal Coliform: If fecal coliform is detected, the contractor shall work with all stakeholders to ensure that the following measures are implemented:

- An investigation of potential sources of contamination, and removal of the contamination, if possible;
- Examination of the well construction will be conducted to ensure that the concrete apron and casing are sealed and in good condition and the wellhead is elevated such that runoff flows away from the concrete pad;
- The well shall be disinfected via the shock chlorination technique.
- Access to the water point may be restricted, if possible, to non-drinking purpose.

Fluoride: If fluoride levels are exceeded, the contractor shall consider the following measures:

- An investigation of the presence of health effects (i.e. dental or skeletal fluorosis), additional sources of fluoride (e.g. brick tea consumption), shall be performed, if possible;
- Alternative low-fluoride sources of water will be used; if possible, and, blending of the two sources shall be considered; or,
- Fluoride treatment shall be considered that is available and economically viable, such as bone charcoal, contact precipitation, clay, activated alumina, calcium chloride, monosodium phosphate, and Nalgonda; or,
- Access to the water point will be restricted to non-drinking purpose.

Nitrate/Nitrite: If nitrate/nitrite levels are exceeded, the contractor shall consider the following measures:

- An investigation of potential sources of contamination, such as nearby agricultural fertilizer application, or leaking septic tanks, will be performed, and removal of the contamination will be completed, if possible; or,
- Access to the water point will be restricted to non-drinking purpose.

OPERATIONAL BASED PARAMETERS

Electrical Conductivity: If electrical conductivity or TDS levels are exceeded, the contractor shall consider the following measures:

- Perform additional testing for individual constituents of conductivity including, chloride, sodium, nitrate, calcium, magnesium, and sulfate, to ensure these constituents are not present at levels above the maximum permissible levels.
- An investigation of potential sources of contamination shall be performed, and removal of the contamination shall be completed, if possible; or,
- Access to the water point will be restricted to non-drinking purpose.

pH: If pH levels are outside of the range, the contractor shall consider the following measures:

- An investigation of potential anthropogenic sources of contamination shall be performed, and an investigation of alternative sources of water supply shall be completed, if possible;
- An investigation of potential natural sources, such as subsurface geology, will be performed, to confirm that the low or high pH is a result of natural conditions;
- If the pH exceedance is due to natural conditions, such as local geology, an investigation of the potential of corrosion of the water supply extraction and distribution infrastructure (e.g. corrosive metal piping and pumping equipment) shall be performed;
- If pH exceedances, could result in corrosion, and leaching of metals from water supply equipment, then testing shall be conducted for metals appropriate water treatment (e.g. neutralizing filter) shall be considered; or,
- Access to the water point will be restricted to non-drinking purpose.

Turbidity: If turbidity levels are exceeded, the contractor shall consider the following measures:

- An investigation of potential sources of contamination, and removal of the contamination, if possible;
- Water treatment that is available and economically viable, such as membrane filters, granular media filters, shall be considered; or,
- Access to the water point will be restricted to non-drinking water purpose.

END OF WQAP